SEISMIC SONAR TECHNOLOGY

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Shallow Water Acoustics

LONG-TERM GOAL

Develop the basic concepts of an active, seismic sonar for the detection of mines and/or unexploded ordnance buried in the surf and near-surf zone.

OBJECTIVE

Test the hypothesis that seismic interface waves can be discretely excited and can be reflected off buried objects, producing detectable echoes.

APPROACH

Develop electromechanical transducers having two, controllable, degrees of vibrational freedom that can discretely excite seismic interface waves. (These are vector waves that require both a horizontal and vertical component in order to be excited.) Test and evaluate these transducers at the Navy beach on Monterey Bay (and elsewhere), after ground truth and noise measurements are made. Develop a rudimentary seismic sonar apparatus for echo ranging tests.

LT Frederick E. Gaghan, USN, an EOD officer, has undertaken this research topic for his MS thesis, which along with his other academic achievements, will earn him masters degrees in Physics and in Engineering Acoustics. LT Gaghan is well into learning the art of military seismology, the theory of elasticity, transducer engineering, and measurement science. He is at the top of his class at the Naval Postgraduate School, and he has also taken and passed the qualifing exam for a PhD in Physics.

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WORK COMPLETED

As of November, 1997, we have developed and tested one, two degree of freedom seismic source, utilizing accelerometer devices, both in a laboratory sand tank and on the NPS baseball diamond. This device utilized two small accelerometers in a transmit mode, mounted to a base plate at a 90 degree angle, the base plate being the coupler to the sediment. We have also developed and tested two other types of two degree sources: one, a bimorph ceramic design, and the other an electromagnetic actuator design. The bimorph consists of two oppositely polarized ceramic wafers, bonded together, and anchored at one end in a cantilevered configuration. The sediment is driven at the opposite end of the device's anchor, much like the motion of a diver's flipper. Bimorphs are capable of producing extremely wide band, short pulse length signals at force level weights measured in the tens of grams. Actuators are normally used to produce large scale movements for industrial applications, but their utility in micro-seismology is quite appealing, since they can a) produce excitations at constant forces, or b) at constant displacements, and c) at force level weights measure in kilograms.

As of this date we have also developed a seismo acoustic testbed at the Navy beach at NPS, where we have made ground truth measurement on seismic interface wave velocities, and on the ambient noise caused by crashing waves.

RESULTS

Although our evaluation of the aforementioned seismic sources is incomplete at the present time, we have enough preliminary data that indicates we will have more than enough amplitude output from the actuators to liquify (overdrive) the sediments, albeit with unknown bandwidth, and that we will have much less amplitude with the bimorphs, albeit with ample bandwidth.

Our ground truth measurements at the NPS beach on Monterey Bay indicate excellent sediment conditions for seismic sonar, with good propagation conditions, and acceptable wave noise conditions that can be dealt with by known signal processing techniques.

IMPACT/APPLICATIONS

This work is significant for the solution of the buried mine problem, for which the Navy now has to rely on the marine mammals, whose care, feeding and logistics is quite involved, costly, and whose sonar search rate is quite low. Seismic sonar is an option to this reliance (as are options developed at the Naval Coastal Systems Station), and these offer man made sonar solutions more appropriate to naval operations.

TRANSITIONS

It is obvious that the 6.1 work discussed here has applications of interest to the undersea and amphibious warfare communities in the 6.2 arena and beyond. The transition has been discussed at the flag level with CNO N85, N87, and with PEO MINES, and most importantly, with other ONR Program Managers, Specifically Dr. Douglas Todoroff.

RELATED PROJECTS

An important related project of the principal investigator is funded by ONR Code 342PS, Drs. Teresa McMullen, Harold Hawkins, and Robert Gisiner. The objective is to discover how Navy dolphins can so easily find buried mines, perhaps with nonlinear sonar, while human engineed systems have failed to so do. In research conducted by the present PI at the Naval Ocean Systems Center (NOSC, now SPAWARESCEN), in cooperation with Dr. Sam Ridgway, it has been found that both bottlenosed dolphins and white whales emit signals with frequency content some **five** times higher than previously measured. The mystery of the marine mammal sonar is yet to be unraveled, and much of the previously published literature is ripe for debate as to its veracity.

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